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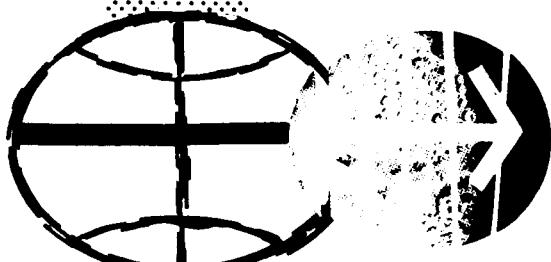
Technical Services Department Inc.

PRELIMINARY ERROR ANALYSIS FOR MISSION AAP 1/2

By Carol Kauffman,

Mathematical Physics Branch

MISSION PLANNING AND ANALYSIS DIVISION



MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

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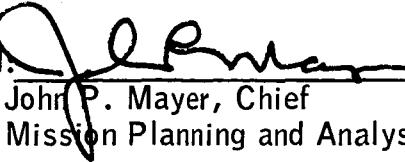
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MISSION PLANNING AND ANALYSIS DIVISION
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

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PRELIMINARY ERROR ANALYSIS FOR MISSION AAP-1/2

by Carol Kauffman

SUMMARY AND INTRODUCTION

This internal note presents the results of an error analysis study of the five rendezvous profiles for the Apollo Applications Program (AAP) Mission AAP-1/2. This mission involves the rendezvous of the command and service modules (CSM) with a Saturn IVB orbital workshop (OWS), which is in a 260-n. mi. circular orbit in all cases. The five rendezvous techniques are described in references 1 and 2; they are the coelliptic, biased-equiperiod, out-of-plane, stable orbit, and elliptic approaches.

This study was made using similar tracking patterns for all five profiles. Uncertainties were calculated at maneuver times and at the beginning of each period of intervehicular tracking. These uncertainties were found to be small for all five cases; the 3 σ position and velocity uncertainties at terminal phase initiation (TPI) were less than 4200 ft and 4.7 fps, respectively.

ANALYSIS

The onboard computer was assumed to be updated by Antigua prior to NCC(t); the NCC state vectors were derived from Manned Space Flight Network (MSFN) tracking. The MSFN tracking of the OWS used only C-band radar, which measures range, azimuth angle, and elevation angle at the rate of one observation per 6 seconds. OWS tracking was begun prior to CSM launch and insertion and continued until approximately 7 minutes before the update time; however, no tracking was assumed during CSM lift-off through insertion.

The MSFN tracking of the CSM utilized S- and C-band radar simultaneously. S-band radar takes range, range rate, and two angle measurements. All measurements were taken at the rate of one observation per 6 seconds. The CSM state was assumed to have been determined from post-NCL tracking with no a priori knowledge for the NCC navigation update.

Intervehicular tracking periods assumed were distinct for each profile. The sextant sighting and CSM maneuver times are given in table I.

The data rate for sextant marks is one observation per minute.

For intervehicular tracking, an initial W matrix of 1000 ft in each position component and 1 fps in each velocity component was used. An observational variance of .04 mrad² was also used. (The relationship between the observational variance and the W matrix is used to regulate the amount that the new data is allowed to correct the current estimate of the state vector.

Uncertainties in MSFN tracking result from uncertainties in each measurement taken, station locations, μ , and drag. The uncertainties assumed are consistent with reference 3; the 1σ uncertainties due to drag are as follows:

CSM, ft/sec ²	4.5×10^{-8}
OWS, ft/sec ²	2.3×10^{-7}

Uncertainties introduced during intervehicular tracking were a result of uncertainties in shaft and trunnion angles, IMU uncertainty due to initial misalignment and drift, and uncertainties in μ , drag, and noise on the shaft and trunnion angles. These are also consistent with reference 3; the IMU uncertainty assumed (1σ) was 0.54×10^{-3} radian in each axis.

RESULTS

The covariance matrices of the CSM state, the OWS state, and the relative state at the CSM maneuver times and prior to each of the periods of intervehicular tracking are presented in table II of the five rendezvous profiles. The following table summarizes the 3σ relative position and velocity uncertainties at these times.

Event	3σ RSS relative state uncertainties	
	Position, ft	Velocity, fps
Coelliptic rendezvous		
NCC(t)	2340	2.2
NSR(t)	4050	4.3
NSR(t) + 39 min	4690	5.4
TPI(t)	2170	2.3
TPI(t) + 3 min	1990	2.1
TPF	1170	1.2
Biased-equip period rendezvous		
NCC(t)	2480	2.6
NSR(t)	4570	4.7
NSR(t) + 26 min	5280	5.7
EPM(t)	2480	3.7
EPM(t) + 54 min	2550	2.8
TPI(t)	3140	3.5
TPI(t) + 3 min	3110	3.5
TPF(t)	3110	3.4
Out-of-plane rendezvous		
NCC(t)	2390	2.3
NSR(t)	3970	4.1
NSR(t) + 10 min	4560	4.6
TPI(t)	4200	4.7
TPI(t) + 10 min	4300	4.8
TPF(t)	1130	1.3
Stable orbit rendezvous		
NCC(t)	2390	2.3
NSR(t)	3970	4.1
NSR(t) + 10 min	4560	4.6
TPI(t)	4200	4.7
TPI(t) + 10 min	4300	4.8
TPF(t)	1130	1.3

Event	3σ RSS relative state uncertainties	
	Position, ft	Velocity, fps
Elliptic orbit rendezvous		
NCC(t)	3240	3.1
NSR(t)	5100	5.5
NSR(t) + 64 min	9230	8.6
TPI(t)	2460	3.1
TPI(t) + 4 min	2940	3.5
TPF	4800	4.9

CONCLUSIONS

By comparing solutions at TPF, it can be seen that the sextant is a more effective aid to rendezvous for the coelliptic, stable orbit, and out-of-plane approaches than for the biased-equiperiod and elliptic orbit approaches.

TABLE I.-- CSM MANEUVER TIMES AND SCHEDULES SEXTANT SIGHTING

(a) Coelliptic rendezvous

Event	Time from CSM insertion, min
CSM Insertion	0
NH(t)	89
NCI(t)	134
NCC(t)	205
NSR(t)	227
TPI(t)	297
TPF(t)	333

Sextant sighting schedule: 21 marks starting at NSR(t) + 39 minutes
 6 marks starting at TPI(t) + 3 minutes

(b) Biased equiperiod rendezvous

Event	Time from CSM insertion, min
CSM insertion	0
NH	88
NCI	133
NCC	205
NSR	227
EPM	291
TPI	386
TPF	422

Sextant sighting schedule: 21 marks starting at NSR(t) + 26 min
 30 marks starting at EPM(t) + 54 min
 6 marks starting at TPI(t) + 3 min

(c) Out-of plane rendezvous

Event	Time from CSM insertion, min
Out-of-plane maneuver	25
NH	88
NCI	133.3
NCC	203.8
NSR	226.8
TPI 1	292.5
TPI 2	323.8
TPF	346.8

Sextant sighting schedule: 21 marks starting at NSR(t) + 10.2 min

10 marks starting at TPI 1(t) + 9.5 min

(d) Stable orbit rendezvous

Event	Time from CSM insertion, min
NH	90
NC 1	134
NCC	208
NSR	228
TPI	276
TPF	340

Sextant sighting schedule: 21 marks starting at NSR(t) + 10 min

7 marks starting at TPI(t) + 10 min

(e) Elliptic orbit rendezvous

Event	Time from CSM insertion, min
NH	90
NC 1	134
NCC	206
NSR	226
TPI	322
TPF	360

Sextant sighting schedule: 19 marks starting at NSR(t) + 64 min

6 marks starting at TPI(t) + 4 min

TABLE II. - COVARIANCE MATRICES OF CSM STATE, OWS STATE, AND

^a
RELATIVE STATE

$$\begin{array}{cccccc}
 \sigma_{xx} & \sigma_{xy} & \sigma_{xz} & \sigma_{x\dot{x}} & \sigma_{x\dot{y}} & \sigma_{x\dot{z}} \\
 & \sigma_{yy} & \sigma_{yz} & \sigma_{y\dot{x}} & \sigma_{y\dot{y}} & \sigma_{y\dot{z}} \\
 & & \sigma_{zz} & \sigma_{z\dot{x}} & \sigma_{z\dot{y}} & \sigma_{z\dot{z}} \\
 \text{Symmetrical} & & & \sigma_{\dot{x}\dot{x}} & \sigma_{\dot{x}\dot{y}} & \sigma_{\dot{x}\dot{z}} \\
 & & & \sigma_{\dot{y}\dot{y}} & \sigma_{\dot{y}\dot{z}} & \\
 & & & & & \sigma_{\dot{z}\dot{z}}
 \end{array}$$

^a The coordinate system for the covariance matrices is as follows:

X is in the direction of the geocentric radius vector of the vehicle at the time of the event.

Z is along the angular momentum vector.

Y completes the right-handed, rectangular Cartesian coordinate system.

The units for position and velocity are feet and feet per second, respectively.

TABLE II. - COVARIANCE MATRICES OF CSM STATE, OWS STATE, AND RELATIVE STATE - Continued

(a) Coelliptic rendezvous

A. NCC (t)

1. OWS covariance

<u>.7309747404</u>	<u>-.4054786504</u>	<u>.4365072404</u>	<u>-.5790001401</u>	<u>-.5651214400</u>	<u>-.2001260401</u>
<u>.1989285305</u>	<u>-.1721842404</u>	<u>-.1740964402</u>	<u>.6360562401</u>	<u>.2020602401</u>	<u>.4677181402</u>
<u>.3276741405</u>	<u>-.1912286401</u>	<u>-.1710857401</u>	<u>.2520702401</u>	<u>.5069917402</u>	<u>.5618009401</u>
	<u>.1820392401</u>	<u>-.7238112402</u>	<u>-.3001546402</u>	<u>.1901957401</u>	<u>.1901957401</u>
		<u>.8019009402</u>	<u>.3461891403</u>	<u>.1198370401</u>	<u>.7846378401</u>

2. CSM covariance

<u>.9991195405</u>	<u>-.1496866406</u>	<u>.6152801405</u>	<u>-.1992877403</u>	<u>-.8526260402</u>	<u>-.2826718402</u>
<u>.2549423406</u>	<u>-.7032187405</u>	<u>.3250232403</u>	<u>.139776403</u>	<u>.5050214402</u>	<u>.4423887402</u>
	<u>.24992946406</u>	<u>-.1059448403</u>	<u>.5891321402</u>	<u>.6317933401</u>	<u>.5618009401</u>
		<u>.4241219400</u>	<u>.1837898400</u>	<u>.8504215401</u>	<u>.2098918401</u>
				<u>.6955239401</u>	

3. Relative state covariance in CSM local coordinate system

<u>.1002936406</u>	<u>-.1441344406</u>	<u>.7263981405</u>	<u>.1936025403</u>	<u>.8426485402</u>	<u>.2318643402</u>
	<u>.2267150406</u>	<u>-.7026966405</u>	<u>.2899681403</u>	<u>.1210258403</u>	<u>.4677181402</u>
		<u>.2831758406</u>	<u>-.1095086403</u>	<u>.6280527402</u>	<u>.5069917402</u>
			<u>.3832782400</u>	<u>.1622294400</u>	<u>.5618009401</u>
				<u>.7Q99252401</u>	<u>.1901957401</u>
					<u>.7846378401</u>

TABLE II. - COVARIANCE MATRICES OF CSM STATE, OWS STATE, AND RELATIVE STATE - Continued

(a) Coelliptic rendezvous - Continued

B. NSR (t)

1. OWS covariance

.7995019+04	-15244022+04	*1478036+04	*5083929+01	*5854635+00	*1178835+01
.5459981+05	*4438519+04	*4656255+02	*4722096+01	*7365951+01	
*9465619+04	*4340214+01	*4391221+00	*4759819+02	*1629263+00	
	*4035661+01	*4368935+02	*2357698+02	*4368935+02	
		*7218847+02	*4081586+01	*4081586+01	

2. CSM covariance

.7531522+05	*3373453+06	*1541200+05	*3360521+03	*5948766+02	*6313746+02
*1763697+07	*8223490+05	*1743905+04	*2922710+03	*2894865+03	
*6483828+05	*8365422+02	*8648345+01	*6378055+02		
	*1726288+01	*2914119+00	*2825375+00		
		*5827578+01	*5838326+01		
			*2999760+00		

3. Relative state covariance in CSM local coordinate system

,7869744+05	*3465838+06	*8154893+04	*3453583+03	*6345572+02	*7459754+02
*1667134+07	*6375598+05	*1652898+04	*2717983+03	*3135485+03	
	*7341594+05	*6395353+02	*4644082+01	*7316622+02	
		*1639937+01	*2712430+00	*3053634+00	
			*5168802+01	*6172928+01	
				*3401289+00	

TABLE II. - COVARIANCE MATRICES OF CSM STATE, OWS STATE, AND RELATIVE STATE - Continued

(a) Coelliptic rendezvous - Continued

C. NSR (t) + 39 min

1. OWS covariance

<u>.58022264+04</u>	<u>.4877630+04</u>	<u>.31114778+03</u>	<u>.5979227+01</u>	<u>.4681081+00</u>	<u>.1518984+00</u>
<u>.216012+05</u>	<u>.3987645+04</u>	<u>.2051250+02</u>	<u>.676318+01</u>	<u>.2833611+01</u>	<u>.1157849+02</u>
<u>.1582822+05</u>	<u>.5078046+01</u>	<u>.1880629+00</u>	<u>.1880629+00</u>	<u>.5157101+04</u>	<u>.7765888+02</u>
<u>.2264625+01</u>	<u>.2264625+01</u>	<u>.765888+02</u>	<u>.9670179+02</u>	<u>.3745905+02</u>	<u>.3287687+01</u>

2. CSM covariance

<u>.5102720+04</u>	<u>.2998688+05</u>	<u>.4036995+05</u>	<u>.3473410+02</u>	<u>.9392462+00</u>	<u>.9434783+01</u>
<u>.2302312+07</u>	<u>.5944433+05</u>	<u>.2680128+04</u>	<u>.1305880+03</u>	<u>.3335105+03</u>	<u>.1165208+03</u>
<u>.1595246+08</u>	<u>.692910+02</u>	<u>.9602809+01</u>	<u>.1515299+00</u>	<u>.3899245+00</u>	<u>.2559455+01</u>
	<u>.3126455+01</u>	<u>.1494580+01</u>	<u>.1494580+01</u>	<u>.1015335+00</u>	<u>.1015335+00</u>

3. Relative state covariance in CSM local coordinate system

<u>.3220728+04</u>	<u>.1350451+05</u>	<u>.7303216+04</u>	<u>.1288476+02</u>	<u>.4186038+01</u>	<u>.7949112+01</u>
<u>.2254961+07</u>	<u>.1019818+06</u>	<u>.2621814+04</u>	<u>.1484425+03</u>	<u>.3432255+03</u>	<u>.1327188+03</u>
<u>.1817634+06</u>	<u>.1175954+03</u>	<u>.1465255+02</u>	<u>.1698425+00</u>	<u>.4024523+00</u>	<u>.2972628+01</u>
	<u>.3053748+01</u>	<u>.1326183+01</u>	<u>.1326183+01</u>	<u>.2045902+00</u>	<u>.2045902+00</u>

TABLE II. - COVARIANCE MATRICES OF CSM STATE, OWS STATE, AND RELATIVE STATE - Continued

(a) Coelliptic rendezvous - Continued

D. TPI (t)

1. OWS covariance

.3664894+06	- .7894904+06	.1166632+06	.9762767+03	- .2555495+03	- .1880176+02
.4878873+07	- .2474023+06	.2253457+04	.5594490+03	.9570535+02	
		.3073686+03	.8723803+02	.7663823+02	
.2523557+06		.2939806+01	.6861820+00	.1104446+00	
			.1935064+00	.2279684+01	
				.1132221+00	

2. CSM covariance

.9026173+05	- .5606237+06	.6009208+05	.6612094+03	- .7574442+02	- .1923280+02
.3715854+07	- .3572424+06	- .4380073+04	.5067174+03	.1381636+03	
	.2376515+08	.4308188+03	.5632747+02	.6869438+02	
		.5168419+01	.5961411+00	.1581357+00	
			.7577025+01	.1230512+01	
				.8458137+01	

3. Relative state covariance in CSM local coordinate system

.1111872+06	.1744781+06	.2276701+03	.1700409+03	.5633314+02	.4773440+00
.3997918+06		.441384+03	.4455700+03	.1018632+03	.923598+00
				.1152817+00	.6865224+01
			.4912522+00	.103823+00	.1031874+02
			.53n4305+n0	.3256874+01	.2418256+03
					.2849725+01

TABLE II. - COVARIANCE MATRICES OF CSM STATE, OWS STATE, AND RELATIVE STATE - Continued

(a) Coelliptic rendezvous - Continued

E. TPI(t) + 3 min

1. OWS covariance

,3996657+06	-,9421601+06	,1122886+06	'1135387+04	-,2850879+03	'6552116+02
,2448992+07	-,2625458+06	'2872894+04	'6825728+03	'1691661+03	
	,2728522+06	'3156846+03	'8692324+02	'1570521+02	
	,3406122+01	'8161308+00	'1959986+00		
		'217996+00	'4355467+01		
			'8786333+01		

2. CSM covariance

,1012834+06	-,6303035+06	'6022979+05	'73083350+03	-,8698515+02	'3383142+02
	,4151485+07	'3470661+06	'4808323+04	'5797760+03	'2262891+03
	,2549526+06	'4107623+03	'5851666+02	'2612780+02	
		'5575338+01	'6708610+00	'2601747+00	
			'8699931+01	'2653027+01	
				'6301027+01	

3. Relative state covariance in CSM local coordinate system

,1211889+06	,1389438+06	'176159+03	'1249430+03	-,6463505+02	'5120569+00
,3014101+06	,5222101+03	'3511954+03	'6194783+02	'8432433+00	
	,1680953+05	'5814565+00	'1614520+00	'8251232+01	
		'4402689+00	'7492612+01	'9398378+03	
			'3881292+01	'2602134+03	
				'2509459+01	

TABLE II. - COVARIANCE MATRICES OF CSM STATE, OWS STATE, AND RELATIVE STATE - Continued

(a) Coelliptic rendezvous - Concluded

F. TPF (t)

1. OWS covariance

.1285112+06	- .1084150+07	- .5867498+05	.1152312+04	- .7136321+02	- .3521599+02
.1087936+08	.5872067+06	".1145778+05	.5985991+03	.3781999+03	
.1041043+06	".6153445+03	".1094170+02	.8645512+02		
	".1208511+02	".6394515+00	".3883551+00		
		.4980921+01	.2422412+01		
			.2753234+00		

2. CSM covariance

.2497983+05	- .3870784+06	- .2426191+05	.4043499+03	- .1285833+02	- .1431985+02
.9399594+07	.5528570+06	- .9817769+04	.2518210+03	.3515546+03	
.8921160+05	- .5751015+03	- .1448818+02	.9291430+02		
	.1025661+02	- .2636207+00	.3579277+00		
		.1616669+01	.1421681+01		
			.2691919+00		

3. Relative state covariance in CSM local coordinate system

.5235085+05	- .6482039+05	.3512709+03	.8393440+02	- .2897140+02	- .1751179+00
.8357335+05	- .4045245+03	.1071275+03	.3719936+02	.2022667+00	
	.1733214+05	.4662855+00	.1676351+00	.4261137+01	
		.1494322+00	.506152+01	.2329161+03	
			.1709552+01	.8374150+04	
				.5014050+02	

TABLE II. - COVARIANCE MATRICES OF CSM STATE, OWS STATE, AND RELATIVE STATE - Continued

(b) Biased equiperiod rendezvous

A. NCC (t)

1. OWS covariance

.6684984+04	-•3075248+04	-•5562294+03	•4266875+01	-•4600278+00	•752571+00
.2459370+05	-•4725232+04	-•2226025+02	•7393625+01	•4644279+01	
	.1999077+05	•4935918+01	-•3324664+01	-•5131782+01	
		•2326310-01	-•8531062-02	-•6922521-02	
			•8373597-02	•2866901-02	
				•1549044-01	

2. CSM covariance

.1197180+06	-•2263809+06	•6199773+05	.2816918+03	-•1141675+03	-•2876225+02
.4756859+06	-•1171587+06	-•5730717+03	•2310301+03	-•5639484+02	
	-•1147431+06	•1466495+03	-•6479306+02	-•2083050+02	
		.7004563+00	-•2853216+00	-•6981451+01	
			.1215502+00	.2846279+01	
				•2044440-01	

3. Relative state covariance in CSM local coordinate system

-•230933+06	-•2217472+06	-•6038630+05	-•2745764+03	-•1073763+03	-•1697552+02
-•4455752+06	-•1054375+06	-•5316030+03	•1974313+03	•3614638+02	
	-•1130793+06	-•1316563+03	-•5337698+02	-•1949294+02	
		•6448762+00	-•2430747+00	-•4474632-01	
			•9552646-01	•1676379-01	
				•3168710-01	

TABLE II. - COVARIANCE MATRICES OF CSM STATE, OWS STATE, AND RELATIVE STATE - Continued

(b) Biased equiperiod rendezvous - Continued

B. NSR (t)

1. OWS covariance

.7319041+04	-3017952+04	-.472630+03	.2923576+01	-.6330304+00	.1963271+01
.5721408+05	*7925673+04	-.5031261+02	.6501331+01	.8473967+01	
*1164732+05	-.8557662+01	*.3437725+01	*.4164925+01		
		.4533820-01	-.6724697-02	-.80384470-02	
			-.7980714-02	*.2562486-02	
				.2579799-01	

2. CSM covariance

*7161139+05	-3775142+06	-.1496420+05	.3756555+03	-.5437327+02	-.5697454+02
.2395502+07	*9331915+05	-.2371217+04	*.3095972+03	*.3256000+03	
*1384132+05	-.9266085+02	*.172228+02	*.1221695+02		
	*.2348735+01	-.3086667+00	*.3202057+00		
		.5169118-01	*.4440281-01		
			*.1485545+00		

3. Relative state covariance in CSM local coordinate system

*7494034+02	-.3839781+06	-.7395476+04	*.3824207+03	-.4902436+02	*.5160740+02
.2201201+07	.5150107+05	-.2191536+04	*.2426498+03	*.2884242+03	
	*.2294723+05	-.5118387+02	*.7309988+01	*.1179504+02	
		.2183098+01	-.2412875+00	*.2854157+00	
			*.3869682-01	*.3202376-01	
				*.1460151+00	

TABLE II. - COVARIANCE MATRICES OF CSM STATE, OWS STATE, AND RELATIVE STATE - Continued

(b) Biased equiperiod rendezvous - Continued

C. NSR(t) + 26 min

1. OWS covariance

.6520423+04	.6588061+04	.2566273+04	-.7323670+01	-.3694187+00	-.2144725+01
.5074563+05	.3624019+04	-.4618920+02	-.5046125+01	-.1346379+02	
		-.4516477+01	.8799243+00	-.5577438+01	
	.1938457+05				
		.4408050-01	.4988200-02	.1327941-01	
			-.8389894-02	-.1596421-02	
				.1621076-01	

2. CSM covariance

.5053513+04	-.4620310+04	.483A732+04	-.6806025+01	-.6842846-01	-.7422856+01
	.3201821+07	.3072294+06	-.3484727+04	-.1335157+03	-.1812139+03
		-.3351221+03	-.1532505+02	-.3121066+02	
		.3799500+01	.1464529+00	.1982075+00	
			-.1317928-01	.8293061-02	
				-.2566434-01	

3. Relative state covariance in CSM local coordinate system

-.670360+04	-.5290287+05	-.3601051+04	.5922049+02	-.3434623+01	-.6415722+00
	.2988392+07	.2810118+06	-.3262669+04	-.1581831+03	-.1221659+03
		-.3070237+03	-.1829969+02	-.2876522+02	
		.1107763+04	.3569644+01	.1741910+00	.1330644+00
				.1111780-01	.5015229-02
					.3630463-01

TABLE II. - COVARIANCE MATRICES OF CSM STATE, OWS STATE, AND RELATIVE STATE - Continued
 (b) Biased equiperiod rendezvous - Continued

D. EPM (t)

1. OWS covariance

.3934794+ub	-.6963951+06	•1098306+06	•1135265+04	-.2789908+03	•1392205+02
.2385914+07	-.2832470+06	-.2909455+04	.6386239+03	-.3576471+02	
.1458796+06	.3448409+03	-.8276577+02		•4807199+02	
	.3594108+01	-.8046465+01	•4479387-01		
		-.2128798+00	-.1202434-01		
			.6689943-01		

2. CSM covariance

.9820621+05	-.6612199+06	•600A578+05	•7802392+03	-.8217784+02	•7540124+01
.4733531+07	-.4169598+06	-.5588156+04	.5883348+03	-.4934454+02	
.1097107+06	-.1097107+06	•4952801+03	•5513548+02	.3633704+02	
		•6603389+01	-.6921590+00	.5996436-01	
			•8037339-01	-.8335063-02	
				.2944311-01	

3. Relative state covariance in CSM local coordinate system

.5642575+03	-.5705803+05	-.8489289+01	•9555477+02	-.4357169+02	-.3464647-01
.5868164+06	.1496252+03	-.8185265+03	-.2072841+03	.7851065+00	
	.3624953+05	-.2140484+00	-.1142439+00	.1121316+02	
		.1154469+01	.2960054+00	-.1140673-02	
			.2960097+00	-.5987818-03	
				.3720887-01	

TABLE II. - COVARIANCE MATRICES OF CSM STATE, OWS STATE, AND RELATIVE STATE - Continued

(b) Biased equiperiod rendezvous - Continued

E. EPM + 54 min

1. OWS covariance

.1306714+06	=.1550165+07	=.4371878+05	.1670312+04	=.5692862+02	.1956621+02
.2401801+08	.7879327+06	-.2591699+05	.4675330+03	-.3099678+03	-.3099678+03
.1628282+06	.8611340+03	.1134530+02	-.1105803+02	-.1105803+02	
	.2798910+02	-.5049008+00	.3393310+00		
		.4558114-01	=.5385305-02		
			.4649457-01		

2. CSM covariance

.5681680+04	=.4161929+05	.2321901+04	.4300893+02	.4707312+00	.9750427+00
	.1290364+08	.6633240+06	-.1401643+05	-.2313223+03	-.2619382+03
		.1204354+06	-.7203736+03	-.1460808+02	-.1579073+02
			.1523172+02	.2525790+00	.2651799+00
				.1211301-01	.5150454-02
					.1790368-01

3. Relative state covariance in CSM local coordinate system

.3970403+06	.1001841+07	-.1799221+03	-.1027721+04	.6685635+03	.5035237+00
	.6039543+07	-.2054817+03	-.6134710+04	.1890578+04	.6003916+00
		.4317556+05	.2169987+00	-.3272850+00	.4114218+01
			.6234700+01	-.1920647+01	-.6250264-03
				.1314134+01	.9260165-03
					.2872111-01

TABLE II. - COVARIANCE MATRICES OF CSM STATE, OWS STATE, AND RELATIVE STATE - Continued

(b) Biased equiperiod rendezvous - Continued

F. TPI

1. OWS covariance

$+11495004+06$	$-11715084+07$	$.6367102+05$	$.1360401+04$	$.1027860+03$	$.5120901+01$
$.15647444+08$	$-.7560302+06$	$-.1794918+05$	$.1020714+04$	$-.5644228+02$	$-.5339584+02$
$+1285871+06$	$-.8739219+03$	$-.5931361+02$	$.5931361+02$	$.3625913+02$	$.3625913+02$
	$.2061125+02$	$-.1189330+01$	$.6646840-01$	$.6646840-01$	
	$-.1063745+00$	$-.6184210-02$	$-.6184210-02$		
		$.5911227-01$	$.5911227-01$		

2. CSM covariance

$+1036158+06$	$-1248063+07$	$.6241153+05$	$.1433092+04$	$.8689816+02$	$.4642591+01$
$.1601540+08$	$-.7758859+06$	$-.1840043+05$	$.1107841+04$	$-.5339584+02$	$-.5339584+02$
$-.1135345+06$	$.8939014+03$	$-.5730738+02$	$.3193084+02$	$.3193084+02$	
	$.2114661+02$	$-.1270094+01$	$.6275979-01$	$.6275979-01$	
		$.8445589-01$	$-.5675935-02$	$-.5675935-02$	
			$.2577935-01$	$.2577935-01$	

3. Relative state covariance in CSM local coordinate system

$.58445450+00$	$.6361671+05$	$-.3863023+03$	$.2218728+02$	$.6213154+03$	$-.86663678+00$
$.4980869+06$	$.6397967+02$	$-.5343784+03$	$-.972084+02$	$.1430461+00$	$.1430461+00$
	$.1456469+05$	$-.1325069+00$	$-.4478931+00$	$.3688374+01$	$.3688374+01$
		$.5894901+00$	$.2041089+00$	$-.2978840-03$	
			$.7188434+00$	$-.1005161-02$	
				$.3310962-01$	

TABLE II. - COVARIANCE MATRICES OF CSM STATE, OWS STATE, AND RELATIVE STATE - Continued

(b) Biased equiperiod rendezvous - Continued

G. TPI + 3 min

1. OWS covariance

.1337784+06	-113.5243+07	.68531<8+05	.1499297+04	-1224077+03	-963a265+01
.1653788+08	-.7754709+06	-.1884175+05	.1166177+04	.1151104+03	
	.13809q0+06	.8880138+03	-.6520536+02	.1587697+02	
		.2148116+02	-.1341712+01	-.130a267+00	
			.1266060+00	.7723960=02	
				.473u596-01	

2. CSM covariance

.1158053+06	-1365347+07	.6612676+05	.1556120+04	-9957600+02	.9809u96+01
.1696510+08	-.7934912+06	-.1934064+05	.1239929+04	.1239496+03	
	.1210229+06	.9063533+03	-.6224048+02	.9103786+01	
		.2205568+02	-.1411312+01	-.1406u68+04	
			.9724308+01	.7779974-02	
				.1644425+01	

3. Relative state covariance in CSM local coordinate system

-6190227+06	-5880789+05	-5733237+03	-3222711+02	-6557887+03	-1048273+01
.4362035+06	.8770871+02	-.4939708+03	-.1070399+03	.1597906+00	
	.1633994+05	-.1972469+00	-.6660225+00	.6042124+01	
		.5771303+00	.2292703+00	-.3617916-03	
			.7652491+00	.1218390+02	
				.3091611-01	

TABLE II. - COVARIANCE MATRICES OF CSM STATE, OWS STATE, AND RELATIVE STATE - Continued

(b) Biased equiperiod rendezvous - Concluded

H. TPF

1. OWS covariance

•4112876+05	-•8975317+06	-•2179679+05	•9599802+03	-•2611691+02	-•2462298+02
.2832900+08	.7189715+06	-•3021014+05	•6540514+03	•8427891+03	*4406530+02
.0607329+05	-•7656541+03	•1590902+02	-•6999472+00	-•8955654+00	-•1965196-01
	•3225099+02	-•2702060-01	.2702060-01	-•1290555+00	

2. CSM covariance

•3318039+05	-•8011705+06	-•1987984+05	•8586977+03	-•2049201+02	-•2191388+02
	.2796731+08	.7258495+06	-•2999165+05	•5742514+03	*4311122+03
	.4375576+05	-•7771582+03	-•1430837+02	.5503000+02	-•8879736+02
		•3216496+02	-•6162451+00	-•2241182-01	*1744659-01
					*1127695+00

3. Relative state covariance in CSM local coordinate system

*1042396+04	-•3727878+06	-•2181383+04	-•1345167+03	-•1134802+04	-•1271175+04
.1039582+05	.8261586+02	-•8440573+01	-•3556443+02	-•4674729-01	
	.2377108+05	-•2730792+00	-•2372868+01	-•1006014+02	
		.4478380-01	.1314349+00	*1578836-03	
			*1245749+01	*1385074-02	
					*1518522-01

TABLE II. - COVARIANCE MATRICES OF CSM STATE, OWS STATE, AND RELATIVE STATE - Continued

(c) Out-of-plane rendezvous

A. NCC

1. OWS covariance

<u>.7602168+04</u>	- .5138260+04	, 6034648+03	.7272351+01	- .1016455+01	, 9102971-02
- .4129569+05	- .3778795+04	- .3582622+02	.9672378+01	, 1561736+01	
- .7915480+05	- .1250460+01	- .5193692+01	.2942590+01		
	, 3473294-01	- .1071361-01	- .1812415-02		
		.8535773-02	.1283077-02		
			, 8920929-02		

2. CSM covariance

<u>.1355924+06</u>	- .2493094+06	.1234716+06	.3029122+03	- .1184687+03	- .7907440+02
, 5021484+06	- .2280147+06	- .5954761+03	.2320443+03	, 1474017+03	
	, 4081686+06	.2761771+03	- .1188907+03	- .5074280+02	
		, 7136619+00	, 2802737+00	- .1785854+00	
			, 1157582+00	, 6713365-01	
				, 1035900+00	

3. Relative state covariance in CSM local coordinate system

<u>.1341087+06</u>	- .2460127+06	.1427520+06	.2985297+03	- .1136089+03	- .7462119+02
, 4998247+06	- .2560071+06	- .5832157+03	.2067039+03	, 1399079+03	
	, 5250645+06	.3069868+03	- .1222907+03	- .4398569+02	
		, 6933217+00	- .2513959+00	- .1690848+00	
			, 6444294-01	, 6326029-01	
				, 1120916+00	

TABLE II. - COVARIANCE MATRICES OF CSM STATE, OWS STATE, AND RELATIVE STATE - Continued

(c) Out-of-plane rendezvous - Continued

B. NSR

1. OWS covariance

$.1005133+05$	$-.4207370+04$	$-.8331653+03$	$.4586539+01$	$-.2528475+01$	$.3129269+01$
	$.4653730+04$	$-.6247725+02$	$.5916610+01$	$-.5742238+01$	
$.1837256+05$	$-.4809969+01$	$.4130221+01$	$.2913657+02$		
	$.5637681+01$	$-.6284573+02$	$.6850678+02$		
		$.8873999+02$	$.9099754+02$		
			$.8416983+01$		

2. CSM covariance

$.9359461+05$	$-.4199528+06$	$-.1990850+05$	$.4189000+03$	$-.7517102+02$	$.11229562+03$
	$.2130503+07$	$.8379935+05$	$.2112391+04$	$.3638654+03$	$.6231378+03$
	$.9382327+05$	$-.8587211+07$	$.1171284+02$	$.8282800+02$	
		$.2096433+01$	$.3631346+00$	$.6136371+00$	
			$.7159448+01$	$.1094253+00$	
				$.4963358+00$	

3. Relative state covariance in CSM local coordinate system

$.9633361+05$	$-.4199568+06$	$-.1035816+05$	$.4203508+03$	$-.7772454+02$	$.11391134+03$
	$.2035364+07$	$.4988282+05$	$.2027515+04$	$.3269284+03$	$.6718466+03$
		$.1190122+06$	$.5063028+02$	$.7669734+01$	$.1290267+03$
			$.2021022+01$	$.3277616+00$	$.6653929+00$
				$.6350468+01$	$.1097141+00$
					$.6184741+00$

TABLE II. - COVARIANCE MATRICES OF CSM STATE, OWS STATE, AND RELATIVE STATE - Continued

(c) Out-of-plane rendezvous - Continued

C. NSR + 10.2 min

1. OWS covariance

.8938829+04	- .1496846+04	.1101621+04	.1643618+00	- .1545467+01	.1853940+01
.7900924+05	- .1646399+04	.6943055+02	.8391351+00	- .1535892+02	
.1241789+05	.1261287+01	.1915919+01		.2096063+02	
	.6202052-01	.2577224+03		.1331644+01	
		.0065041-02		.8677322+02	
				.9154721+01	

2. CSM covariance

.3585560+05	- .2788456+06	.4695077+05	.2745513+03	- .2041616+02	.3954600+02
.2979010+07	.4936034+06	.2932507+04	.1863088+03	.4989873+03	
	.1424360+06	.4854202+03	.2836168+02	.1494752+03	
		.2888096+01	.1838595+00	.4856452+00	
			.2118717+01	.3056575+01	
				.13356354+00	

3. Relative state covariance in CSM local coordinate system

.3726636+05	- .2986436+06	.4927029+03	.2931493+03	- .2415875+02	.5629087+02
.2861632+07	.4947569+06	.2827661+04	.1663471+03	.5737076+03	
.1561232+06		.4680294+03	.2643409+02	.1798836+03	
		.2795856+01	.1621607+00	.5652852+00	
			.1751477+01	.3046436+01	
				.5720153+00	

TABLE II. - COVARIANCE MATRICES OF CSM STATE, OWS STATE, AND RELATIVE STATE - Continued

(c) Out-of-plane rendezvous - Continued

D. TPI

1. OWS covariance

,5193896+06	-1407773+07	.178846C+C6	.1681197+04	-.3954327+03	*3068767+02
	,4069143+07	-.5528989+C6	-.4891279+04	.1062867+04	-.9641322+02
		,3855535+C6	.6837119+03	-.1325349+03	.1536891+03
			,5900391+01	-.1260868+01	.1228714+00
				.3163210+00	-.3075956-01
					.2701680+00

2. CSM covariance

,8458675+05	-.5537630+06	.1099235+06	.6693289+03	-.6727524+02	1855457+02
	.3899784+07	-.7367327+06	-.4711522+04	.4733761+03	-.1166190+03
		,3258493+06	.8948419+03	-.9492520+02	.1664682+03
			.5696811+01	-.5705881+00	.1457754+00
				.6543805-01	-.2370498-01
					.2069024+00

3. Relative state covariance in CSM local coordinate system

,3422190+06	-.6268798+06	-.2122986+03	.7320040+03	-.2540238+03	.8985652+00
	,2980356+07	-.5480301+03	-.2435869+04	.4950757+03	.2268493+01
		,6434729+05	.6265408+00	.1001948+00	-.1398207+02
			.2865086+01	-.2716427+00	-.2580303+02
				.1950545+00	-.4299470+03
					.6013851-01

TABLE II. - COVARIANCE MATRICES OF CSM STATE, OWS STATE, AND RELATIVE STATE - Continued

(c) Out-of-plane rendezvous - Continued

E. TPI + 9.5 min

1. OWS covariance

5854727+06 - 2125859+07 - 1858016+06 - 258363+04 - 4522505+03 - 1064325+03
 7900036+07 - 6874510+06 - 8759498+04 - 1667354+04 - 3909450+03 - 3909450+03
 ,4588048+06 - 9872956+03 - 1517818+03 - 4284869+02 - 4284869+02
 9760352+01 - 1843258+01 - 1843258+01 - 4476125+00 - 4476125+00
 ,3626155+00 - 3626155+00 - 3626155+00 - 7759781-01 - 7759781-01
 1795533+00 - 1795533+00 - 1795533+00

2. CSM covariance

-1315203+06	-8318389+06	-1246258+06	-9544427+03	-1146527+03	-7231295+02
,5499660+07	-7875834+06	-6302192+04	-7650408+03	-7650408+03	-4675873+03
	-4119422+06	-9033553+03	-1196001+03	-1196001+03	-3629595+02
		-7227595+01	-8763583+00	-8763583+00	-5357016+00
			-1121986+00	-1121986+00	-6062454+01
					-9858865+01

3. Relative state covariance in CSM local coordinate system

- .32960083+06	- 98358481+06
- 6021936+03	- 4882949+05
- 6622452+03	- 411666959+04
- 6622452+03	- 411666959+04
- 1019249+04	- 4482460041
- 818535383+00	- 9707608+03
- 1951899+00	- 1951899+00
- 1250820+02	- 225969-02
- 1250820+02	- 1970764+01
- 225969-02	- 1970764+01
- 225969-02	- 1970764+01
- 2434622+03	- 1970764+01
- 18354941+00	- 1970764+01

TABLE II. - COVARIANCE MATRICES OF CSM STATE, OWS STATE, AND RELATIVE STATE - Continued

F. TPI 2

1. OWS covariance

5178234+00	5178234+00
9671436-01	9671436-01
7142414-01	7142414-01
-11370052+01	-11370052+01
-5262892+00	-5262892+00
-11310575+04	-11310575+04
-2982675+02	-2982675+02
-7906517+03	-7906517+03
-1118331+05	-1118331+05
-455741+05	-455741+05
-1115694+07	-1115694+07
-1260799+06	-1260799+06
-1081817+08	-1081817+08
-8617079+05	-8617079+05
-11200517+02	-11200517+02
-8454086+00	-8454086+00
-2982675+02	-2982675+02
-7906517+03	-7906517+03
-1118331+05	-1118331+05
-455741+05	-455741+05
-1118227+04	-1118227+04
-8588867+02	-8588867+02
-1131727+03	-1131727+03

2. CSM covariance

3. Relative state covariance in CSM local coordinate system

- .9439292+04	- .9519177+02	- .5276357+01	- .5050681-01
- .6231483+04	- .6818600+02	- .5279257+01	- .3633015-01
- .7992048+04	- .7849836+01	- .3320051-01	- .7198272+01
- .4451434+01	- .1740931-01	- .4054250-04	- .1763135-04
- .68894526-02	-	-	- .7366197-02

TABLE II. - COVARIANCE MATRICES OF CSM STATE, OWS STATE, AND RELATIVE STATE - Continued

(c) Out-of-plane rendezvous - Concluded

G. TPF

1. OWS covariance

,2522010+05	-14258395+06	-1,2793092+05	,4578067+03	-1,8463129+01	'2121717+02
11410455+08	1335605+07	-1,1538030+05	-1,683865+02	-15336011+03	
,4180797+06	-1459849+04	-1,1323694+02	11147387+02		
	,1678727+02	,3287232+01	15847357+00		
		,2306899+01	12612184+02		
			11070431+00		

2. CSM covariance

,7214049+04	1097345+05	1897767+05	-1,9996061+02	-3010310+01	11181904+01
11192900+08	1237506+07	-1,1265782+05	-318978+03	-1495430+03	
,4156735+06	-1334229+04	-1,3997353+02	1674589+02		
	,1386310+02	,3448553+00	15352831+00		
		,1669934+01	1425926+01		
			19820000+01		

3. Relative state covariance in CSM local coordinate system

,2347276+03	-16415478+05	7168335+02	7088284+02	-1955458+02	1590446+00
12115104+06	-1585278+03	-2109367+03	,6531824+02	3517523+00	
,6305939+04	-2034438+00	-4405320+01	7246108+01		
	.2228633+00	-6409232+01	-4499045+03		
		,2077857+01	19849919+04		
			,9420051-02		

TABLE II. - COVARIANCE MATRICES OF CSM STATE, OWS STATE, AND RELATIVE STATE - Continued

(d) Stable orbit rendezvous

A. NCC (t)

1. OWS covariance

<u>.6639457+04</u>	<u>-.5166590+04</u>	<u>,9620490+03</u>	<u>,5925802+01</u>	<u>-,3689051+00</u>	<u>-,2140772+01</u>
<u>.2651616+05</u>	<u>-,1105996+04</u>	<u>-,2333214+02</u>	<u>,7623799+01</u>	<u>,3188253+01</u>	
<u>,1750900+05</u>	<u>-,1820211+00</u>	<u>-,1311770+01</u>	<u>-,2529255+01</u>		
	<u>.2256422+01</u>	<u>-,8188881+02</u>	<u>,3340809-02</u>		
		<u>,8311467+02</u>	<u>,4252250+02</u>		
			<u>,1333100-01</u>		

2. CSM covariance

<u>1034984+06</u>	<u>-,1799381+06</u>	<u>,4647226+05</u>	<u>,2221052+03</u>	<u>-,8894024+02</u>	<u>,3442998+02</u>
	<u>,3584824+06</u>	<u>-,5121356+05</u>	<u>-,4251955+03</u>	<u>,686826+03</u>	<u>,5449255+02</u>
		<u>,2262152+06</u>	<u>,489996+02</u>	<u>,582782+02</u>	<u>,1108425+02</u>
			<u>,5133785+00</u>	<u>,2063224+00</u>	<u>,7000942-01</u>
				<u>,8868642+01</u>	<u>,2600899-01</u>
					<u>,7129693-01</u>

3. Relative state covariance in CSM local coordinate system

<u>,1019345+06</u>	<u>-,1707455+06</u>	<u>,5171498+05</u>	<u>,2121829+03</u>	<u>-,8587440+02</u>	<u>,2873842+02</u>
	<u>,3111852+06</u>	<u>-,4323495+05</u>	<u>,3736737+03</u>	<u>,1435107+03</u>	<u>,4832862+02</u>
		<u>,2225423+06</u>	<u>,6852441+02</u>	<u>,4486524+02</u>	<u>,1395463+02</u>
			<u>,4371583+00</u>	<u>,1782277+00</u>	<u>,5973338+01</u>
				<u>,7242904-01</u>	<u>,2444117+01</u>
					<u>,8177833+01</u>

TABLE II. - COVARIANCE MATRICES OF CSM STATE, OWS STATE, AND RELATIVE STATE - Continued

(d) Stable orbit rendezvous - Continued

B. NSR (t)

1. OWS covariance

<u>.6548725+04</u>	<u>-.1444023+04</u>	<u>-.1197132+04</u>	<u>.1640045+01</u>	<u>.1694083+00</u>	<u>.1034743+01</u>
<u>.5300883+05</u>	<u>.446403+04</u>	<u>-.4515505+02</u>	<u>.2936511+01</u>	<u>.2514683+01</u>	
<u>.1010697+05</u>	<u>-.4183953+01</u>	<u>-.4313850+00</u>	<u>.5419977+00</u>		
	<u>.3909062+01</u>	<u>-.3175220+02</u>	<u>-.7408512+03</u>		
		<u>.7230398+02</u>	<u>-.1345515+02</u>		
			<u>.2249034+01</u>		

2. CSM covariance

<u>.6984959+05</u>	<u>-.3164449+06</u>	<u>-.1709324+05</u>	<u>.3136812+03</u>	<u>-.5427625+02</u>	<u>.5088711+02</u>
<u>.1730643+07</u>	<u>.7602497+05</u>	<u>-.1701979+04</u>	<u>.2717339+03</u>	<u>.2175832+03</u>	
<u>.7114150+05</u>	<u>-.7752202+02</u>	<u>.9587254+01</u>			
		<u>.1675667+01</u>	<u>-.2696729+00</u>	<u>-.2100818+00</u>	
			<u>.5331202+01</u>	<u>.4725099+01</u>	
				<u>.2634502+00</u>	

3. Relative state covariance in CSM local coordinate system

<u>.6969003+05</u>	<u>-.1206680+06</u>	<u>.0202492+04</u>	<u>.3177091+03</u>	<u>-.5507017+02</u>	<u>.5684020+02</u>
<u>.1598951+07</u>	<u>.9036196+05</u>	<u>-.1576735+04</u>	<u>12463814+03</u>	<u>12141670+03</u>	
	<u>.8010715+05</u>	<u>-.5774658+02</u>	<u>.5620268+01</u>	<u>.5182786+02</u>	
		<u>.1559766+01</u>	<u>-.2443603+00</u>	<u>-.2066460+00</u>	
			<u>.4394411+01</u>	<u>.4762818+01</u>	
				<u>.2582450+00</u>	

TABLE II. - COVARIANCE MATRICES OF CSM STATE, OWS STATE, AND RELATIVE STATE - Continued

(d) Stable orbit rendezvous - Continued

C. NSR (t) + 10 min

1. OWS covariance

<u>.6708762+04</u>	<u>.2524491+04</u>	<u>.5476843+03</u>	<u>-.2634732+C1</u>	<u>-.2481938+01</u>	<u>.2016373+01</u>
<u>.5271492+05</u>	<u>.3846549+C4</u>	<u>-.4541511+02</u>	<u>-.1996548+01</u>	<u>-.2966158+01</u>	
	<u>.1366769+05</u>	<u>-.3118693+01</u>	<u>-.2100081+01</u>	<u>.4483749+01</u>	
		<u>.3972246-n1</u>	<u>.1840494+02</u>	<u>.3450991-02</u>	
			<u>.7466469+02</u>	<u>-.1184744-02</u>	
				<u>.1808055-01</u>	

2. CSM covariance

<u>.2787648+05</u>	<u>-.2015594+06</u>	<u>-.2456587+05</u>	<u>-.1974148+03</u>	<u>-.1492279+02</u>	<u>-.1309527+02</u>
<u>.2339653+07</u>	<u>.2180394+06</u>	<u>-.2295726+04</u>	<u>.1298059+03</u>	<u>.1460475+03</u>	
	<u>.7971052+05</u>	<u>-.2111308+03</u>	<u>.1482265+02</u>	<u>.6440868+02</u>	
		<u>.2254051+01</u>	<u>-.1274743+00</u>	<u>-.1345425+00</u>	
			<u>.1176079+01</u>	<u>.1378272-01</u>	
				<u>.2528407+00</u>	

3. Relative state covariance in CSM local coordinate system

<u>.2561417+05</u>	<u>-.2199328+06</u>	<u>-.2137524+05</u>	<u>.2153318+03</u>	<u>-.1566841+02</u>	<u>-.1232795+02</u>
<u>.2199846+07</u>	<u>.1982763+06</u>	<u>-.2162157+04</u>	<u>.1161277+03</u>	<u>.1643654+03</u>	
	<u>.8405099+05</u>	<u>.1903451+03</u>	<u>.1231234+02</u>	<u>.1573964+02</u>	
		<u>.2126253+01</u>	<u>-.1131322+00</u>	<u>.1527673+00</u>	
			<u>.1069560-n1</u>	<u>.1624513+01</u>	
				<u>.2533634+00</u>	

TABLE II. - COVARIANCE MATRICES OF CSM STATE, OWS STATE, AND RELATIVE STATE - Continued

(d) Stable orbit rendezvous - Continued

D. TPI (t)

1. OWS covariance

<u>.2203557+05</u>	<u>-.2732205+05</u>	<u>'6498459+04</u>	<u>'4727914+02</u>	<u>-.1012246+02</u>	<u>'2411433+01</u>
<u>.1035693+06</u>	<u>-.4860460+04</u>	<u>'1328943+03</u>	<u>'1200872+02</u>	<u>'3608502+01</u>	
<u>.7129266+05</u>	<u>'1354100+02</u>	<u>'2513793+01</u>	<u>'4201005+02</u>		
	<u>.2027425+00</u>	<u>'2015555+01</u>	<u>'3505523+01</u>		
	<u>.1622402+01</u>	<u>'1090035+01</u>			
		<u>'2753188+00</u>			

2. CSM covariance

<u>'8690322+04</u>	<u>-.7340119+05</u>	<u>'6802519+04</u>	<u>'9099383+02</u>	<u>-'9968950+00</u>	<u>'1957759+01</u>
<u>.2137882+07</u>	<u>-.1102199+06</u>	<u>-.2599292+04</u>	<u>'4082226+01</u>	<u>'2103967+03</u>	
<u>.6711435+05</u>	<u>'1306095+03</u>	<u>'2145539+01</u>	<u>'4301963+02</u>		
	<u>.3165529+01</u>	<u>'3327274+02</u>	<u>'2737861+00</u>		
		<u>'1005435+01</u>	<u>'1037036+01</u>		
			<u>'2660575+00</u>		

3. Relative state covariance in CSM local coordinate system

<u>.1501807+05</u>	<u>-.2058778+05</u>	<u>-.8288301+00</u>	<u>'4023985+02</u>	<u>'9056473+01</u>	<u>'5496476+01</u>
<u>.1936392+07</u>	<u>'6066214+03</u>	<u>'2158157+04</u>	<u>'2225424+02</u>	<u>'1230203+00</u>	
	<u>.5081328+04</u>	<u>'6748079+00</u>	<u>'2432751+02</u>	<u>'3080346+00</u>	
		<u>'2412776+01</u>	<u>'3034063+01</u>	<u>'1367750+03</u>	
			<u>'5673722+02</u>	<u>'7936001+06</u>	
				<u>'6730542+02</u>	

TABLE II. - COVARIANCE MATRICES OF CSM STATE, OWS STATE, AND RELATIVE STATE - Continued

(d) Stable orbit rendezvous - Continued

E. TPI(t) + 10 min

1. OWS covariance

<u>.5520484+05</u>	<u>-.6356703+05</u>	<u>.2095159+05</u>	<u>.1287671+03</u>	<u>-.3784439+02</u>	<u>.7319617+01</u>
<u>.2116256+06</u>	<u>-.1446024+05</u>	<u>-.2797065+03</u>	<u>.6254855+02</u>	<u>.1519143+00</u>	
<u>.9250757+05</u>	<u>.4757519+02</u>	<u>-.1108461+02</u>	<u>.7196372+02</u>		
	<u>.4005373+00</u>	<u>-.9543075+01</u>	<u>.2496304+01</u>		
		<u>.3783025+01</u>	<u>-.8393836+02</u>		
			<u>-.2490831+00</u>		

2. CSM covariance

<u>.3161715+05</u>	<u>-.2456128+06</u>	<u>.2115049+05</u>	<u>.3020899+03</u>	<u>-.2008062+02</u>	<u>.7333882+01</u>
<u>.2445397+07</u>	<u>-.2172478+06</u>	<u>-.3002465+04</u>	<u>.1834735+03</u>	<u>-.9605117+02</u>	
<u>.6616532+05</u>	<u>.2725876+03</u>	<u>-.1139480+02</u>	<u>.6989709+02</u>		
	<u>.3690352+01</u>	<u>-.2246198+00</u>	<u>.1317692+00</u>		
		<u>.1241086+01</u>	<u>-.8442806+02</u>		
			<u>.2424556+00</u>		

3. Relative state covariance in CSM local coordinate system

<u>.2543833+05</u>	<u>-.5233807+05</u>	<u>.3901694+00</u>	<u>.6582754+02</u>	<u>-.1817393+02</u>	<u>.12230871+03</u>
<u>.2026774+07</u>		<u>.4295889+03</u>	<u>.223637+02</u>	<u>.4251729+02</u>	<u>-.4070357+00</u>
		<u>.5488017+04</u>	<u>-.4756908+00</u>	<u>.9165267+03</u>	<u>.2665075+00</u>
			<u>.2517832+01</u>	<u>-.5312294+01</u>	<u>.4513088+03</u>
				<u>.1351086+01</u>	<u>-.1947960+05</u>
					<u>.6227156+02</u>

TABLE II. - COVARIANCE MATRICES OF CSM STATE, OWS STATE, AND RELATIVE STATE - Continued

(d) Stable orbit rendezvous - Concluded

F. TPF (t)

1. OWS covariance

<u>.1671543+05</u>	<u>-.1529584+06</u>	<u>-.8235911+04</u>	<u>.1603942+03</u>	<u>-.5074117+01</u>	<u>.5491386+01</u>
<u>.83882666+07</u>	<u>.4783499+06</u>	<u>-.8820172+04</u>	<u>-.2633812+02</u>	<u>.2315309+01</u>	<u>.9273003+02</u>
<u>.1633131+06</u>	<u>-.4944543+03</u>	<u>-.2334902+01</u>	<u>.4039947-02</u>		
	<u>.9277954+01</u>	<u>.2774397-01</u>	<u>.1165545+01</u>	<u>.1796348+03</u>	<u>.1631153+00</u>

2. CSM covariance

<u>.1092279+05</u>	<u>-.1494228+06</u>	<u>* 9181221+04</u>	<u>.1563377+03</u>	<u>-.2047073+01</u>	<u>.5518384+01</u>
<u>.8866362+07</u>	<u>.4946385+06</u>	<u>-.9376104+04</u>	<u>-.4938746+01</u>	<u>.6308157+00</u>	<u>.9082341+02</u>
<u>.1586938+06</u>	<u>-.5148254+03</u>	<u>-.2781001+00</u>	<u>.1939069+02</u>	<u>.7258147-02</u>	<u>.1080751-03</u>
	<u>.9918161+01</u>	<u>.16107354+02</u>	<u>.1928381+00</u>		

3. Relative state covariance in CSM local coordinate system

<u>.6645052+04</u>	<u>-.2556290+05</u>	<u>.1695070+00</u>	<u>.2021063+02</u>	<u>-.3114510+01</u>	<u>.7852758+02</u>
<u>.13000823+06</u>	<u>.2059016+01</u>	<u>* .1456435+03</u>	<u>.1732102+02</u>	<u>.6363928+01</u>	<u>.5161655+00</u>
	<u>.4439312+04</u>	<u>* .3549013-02</u>	<u>.6734953-02</u>	<u>.1971726+01</u>	<u>.8200758+04</u>
		<u>* .1635398+00</u>	<u>.2738189-02</u>	<u>.2046542+04</u>	<u>.7805627+02</u>

TABLE II. - COVARIANCE MATRICES OF CSM STATE, OWS STATE, AND RELATIVE STATE - Continued

(e) Elliptic orbit rendezvous

A. NCC (t)

1. OWS covariance

.7588243+04	-•2112425+04	•3280012+03	•4761604+01	-•7631882+00	•8860365+00
	-•2866971+05	-•2355313+04	-•2254637+02	•6707190+01	•4938683+01
			•3062966+01	-•3367920+01	-•5788059+01
			•2267212-01	-•8245109-02	-•2289275-02
				•8036831-02	-•9449013-04
					•1381846-01

2. CSM covariance

•1604137+06	-•3080546+06	•1579163+06	•3804922+03	-•1507925+03	-•6382401+02
	-•6537192+06	-•2854291+06	-•7831800+03	•3057217+03	•1178314+03
		•4206849+06	•3639944+03	-•1566431+03	-•976833+02
			•9501822+00	-•3749415+00	-•1485672+00
				•1538623+00	-•5972217-01
					•6352461-01

3. Relative state covariance in CSM local coordinate system

•1572106+06	-•2913640+06	•1516269+06	•3591650+03	-•1413023+03	-•6231687+02
	•5971281+06	-•2538077+06	-•7072291+03	•2616127+03	•1154549+03
		•4083023+06	•3258459+03	-•1387243+03	-•9672495+02
			•8541800+00	-•3231610+00	-•1410761+00
				•1294806+00	•5430011-01
					•7651449-01

TABLE II. - COVARIANCE MATRICES OF CSM STATE, OWS STATE, AND RELATIVE STATE - Continued

(e) Elliptic orbit rendezvous - Continued

B. NSR (t)

1. OWS covariance

.1234345+05	-.7929112+04	.2815941+04	.8374429+01	-.4868741+01	.1340708+01
.5803758+05	-.1873863+04	-.5162194+02	.9412132+01	.6688860+01	
.9247204+04	.1954694+01	-.3055843+01	.3081672+01		
	.4706379-01	-.1019425-01	-.5612029-02		
		.1129241-01	.1968417-02		
			.2629064-01		

2. CSM covariance

.1066075+06	-.5245705+06	-.1757898+05	.5238645+03	-.8700644+02	-.1542698+03
+2984325+07	.8878770+05	-.2965116+04	.4525731+03	.8019265+03	
	.3090310+05	-.8925109+02	.1269931+02	.7743781+00	
		.2947888+01	-.4524408+00	-.7969609+00	
			.8140333-01	.1377917+00	
				.5559968+00	

3. Relative state covariance in CSM local coordinate system

.1083109+06	-.5102451+06	-.1393853+05	.5108990+03	-.8575217+02	-.1506383+03
.2736179+07	.8805670+05	-.2725934+04	.4038909+03	.7361015+03	
	.4051273+05	-.8674090+02	.9085178+01	.5382580+01	
		.2717560+01	-.4043422+00	-.7326005+00	
			.7123104-01	.1249361+00	
				.5412642+00	

TABLE II. - COVARIANCE MATRICES OF CSM STATE, OWS STATE, AND RELATIVE STATE - Continued

(e) Elliptic orbit rendezvous - Continued

C. NSR (t) + 64 min

1. OWS covariance

.6141225+04	-1460684+04	.3648926+03	.1558771+01	-.3504050+00	-.9873786+00
.2074000+05	-.3059766+04	-.2158138+02	.6066565+01	.1789849+01	
	.2119167+05	.2961908+01	-.3240753+01	.3224263+01	
		.3018318-01	-.4763156-02	.1200871-02	
			.8914412-02	-.3103653-03	
				.1151462-01	

2. CSM covariance

.1030526+06	-.7423195+06	.1246388+06	.8999620+03	-.9346591+02	.3379795+02
.56659991+07	-.9521399+06	-.6871965+04	.7102950+03	-.2606510+03	
	.3900014+06	.1167287+04	-.1185602+03	.1557043+03	
		.8342017+01	-.85885167+00	.32206355+00	
			.9695594-01	-.3544630-01	
				.1062182+00	

3. Relative state covariance in CSM coordinate system

.1054296+06	-.7566022+06	.1234452+06	.9117079+03	-.8969012+02	.3115234+02
.5521920+07	-.9015976+06	-.6666470+04	.6394175+03	-.2355542+03	
	.38442458+06	.1102026+04	-.1032722+03	.1443275+03	
		.8060230+01	-.7692764+00	.2932578+00	
			.7696757-01	-.2607677-01	
				.1102018+00	

TABLE II. - COVARIANCE MATRICES OF CSM STATE, OWS STATE, AND RELATIVE STATE - Continued

(e) Elliptic orbit rendezvous - Continued

D. TPI (t)

1. OWS covariance

.3708781+06	-1559394+07	-6562029+05	.1909564+04	-.6278816+02	-.2038388+03
.1088306+08	.4595166+06	-.1195194+05	-.2224385+02	.1459127+04	
	.2398769+05	-.5002270+03	-.1642283+01	.1291927+03	
		.1341841+02	-.5830495-01	-.1581855+01	
			.4338421-01	.5453983-02	
				.5688080+00	

2. CSM covariance

.8664287+05	-1040826+07	-.4248051+05	.1101231+04	-.6545803+02	-.1298674+03
	.1448342+08	.5462112+06	-.1530346+05	.8378028+03	.1691720+04
		.5122959+05	-.5776715+03	.3281897+02	.997304+02
			.1617253+02	-.8872515+00	-.1784427+01
				.5939675-01	.1097531+00
					.5295280+00

3. Relative state covariance in CSM local coordinate system

.2821460+06	.9388889+05	.1250040+04	.1750151+03	.8786205+02	.7427879+00
	.3429637+06	.2007158+04	-.4176531+03	.2518124+03	.1189043+01
		.4433857+05	-.1660693+01	.1551721+01	.3454274+02
			.8437364+00	-.2800433+00	-.9838713-03
				.1938212+00	.9218427-03
					.4566095-01

TABLE II. - COVARIANCE MATRICES OF CSM STATE, OWS STATE, AND RELATIVE STATE - Continued

(e) Elliptic orbit rendezvous - Continued

E. TPI(t) + 4 min

1. OWS covariance

.4896860+06	-1733040+07	-1109856+06	.2249486+04	-.1584035+03	-.1751691+03
.1175556+08	.8184816+06	-.1355568+05	.6522025+02	.1320014+04	
	.1785363+06	-.9270872+03	-.7976846+00	.2146759+03	
		.1592623+02	-.2313346+00	-.1489699+01	
			.1080430+00	.3679743-02	
				.4640846+00	

2. CSM covariance

.5837271+05	-8469857+06	-.5731587+05	.8938154+03	-.3956796+02	-.8904616+02
	.1534294+08	*9571982+06	-.1619281+05	.6209389+03	.1516699+04
		.1230169+06	-.1008918+04	.4216445+02	.192106+03
			.1709205+02	-.6560592+00	-.1595446+01
				.3640041-01	.7073772-01
					.4398897+00

3. Relative state covariance in CSM local coordinate system

.4561433+06	-4281729+03	*1600764+04	*4485852+03	*2278507+01	*2281319+00
	.4454586+06	*2180980+04	-.5457856+03	*2967742+03	*3067153+00
		.5962017+05	-.1119061+01	*1484480+01	*2760879+02
			*1118711+01	-.3577314+00	-.1585429-03
				*2010356+00	*2128053-03
					*2673081-01

TABLE II. - COVARIANCE MATRICES OF CSM STATE, OWS STATE, AND RELATIVE STATE - Concluded

(e) Elliptic orbit rendezvous - Concluded

F. TPF (t)

1. OWS covariance

.7498168+06	-.4205988+07	-.7742370+05	.4958691+04	-.5249650+03	.3447756+05
	.2689977+08	.5550064+06	-.3151938+05	.2930816+04	-.2343439+04
		.1027544+06	-.6496876+03	.5459021+02	-.1672557+03
			.3695044+02	-.3457265+01	-.2741017+01
				.3793118+00	-.2361111+00
					.4898634+00

2. CSM covariance

.6794450+04	-.1415449+06	.1341380+04	.1644595+03	-.1174731+00	.7331891+01
	-.1597749+08	.4213991+06	-.1831558+05	-.1600051+03	-.1819773+04
		.8759242+05	-.4834280+03	-.6654783+01	-.1577208+03
			.2100292+02	.1805847+00	.2084435+01
				.1208690-01	.2690652-01
					.4801474+00

3. Relative state covariance in CSM local coordinate system

.1086455+07	-.1245779+07	-.2641766+04	.1657036+04	-.3968082+03	-.4995245+00
	.1455090+07	.3058347+04	-.1920811+04	.4525174+03	.5757443+00
		.1396765+05	-.4012239+01	.8606445+00	-.7503173+01
			.2545124+01	-.6070482+00	-.7535336-03
				.1560776+00	.1584071-03
					.1145171-01

REFERENCES

1. McDonnell Astronautics Company: Airlock Technical Directive No. 2, Phase I Report Guidance and Control Mechanics. Airlock Design Note No. 3, June 5, 1967.
2. Hartley, Larry D.: Catch-up logic for the various rendezvous profiles proposed by McDonnell Astronautics Company for AAP-1/2. MSC Memorandum 67-FM62-247, December 19, 1967.
3. Apollo Navigation Working Group: Apollo Missions and Navigation Systems Characteristics. ANWG Technical Report No. AN-1.2, January 17, 1967.